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# DNA MASTER FILE OF GROUND-SHOCK, AIR-BLAST, AND STRUCTURE-RESPONSE DATA

Volume 2: Appendixes

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TECHNICAL  
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Data Display	Height-of-Burst Tests	DISTANT PLAIN MINE THROW PRE-MINE THROW IV
Data Management	Structure Response	FLAT TOP MINE UNDER PRAIRIE FLAT
Data Processing	DATA/70S	MIDDLE GUST MINERAL LODGE SAILOR HAT
Ground Shock	DIAL PACK	MIDDLE NORTH MINERAL ROCK SNOWBALL
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A master file of air-blast, ground-shock, and structure-response data was created from selected high-explosive field tests. The computer software used in forming and maintaining the master file is described and the available processing options are discussed. A compilation of data not included in the master file is also presented.		

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## SUMMARY

For more than a decade, measured air-blast, ground-motion, and structure-response data have been acquired from a variety of high-explosive field tests. *Volume 1: Archive Description and User's Information* summarizes the activities of the past several years to locate and acquire some of the most important groups of these data, preparatory to general accessing by users.

A brief background of the tests that contributed to the formation of the master file of data is presented, together with an extensive bibliography of relevant published documents. Also discussed are the identification system used in cataloging the data, the documentation procedure describing the master file content, the procedures required to retrieve data from the archive, and the various output formats available to the potential user. The descriptive material is accompanied by various illustrations, and an example case is presented to demonstrate the retrieval, processing, and plotting procedures.

*Volume 2: Appendixes* presents a summary of the data available at Physics International Company; and a detailed description of the computer software used in forming and maintaining the data archive. The various processing options available to reduce, reformat, and analyze data are included.

## PREFACE

The formation of the master file of high-explosive data described in this report and the use of the data management and data processing software to retrieve, process, and display the data were authorized and supported by the Defense Nuclear Agency. Major R. Waters was the Contracting Officer's Representative (COR) during the early part of the program. Lt Col. D. Burgess was the COR for the remainder of the work. The initial effort was performed under Contract No. DNA001-73-C-0058, NWE T Subtask Code L17DAXSX318, Work Unit Code 01 and NWE D Subtask Code Y99QAXSD164, Work Unit Code 01. The work was completed under Contract No. DNA001-75-C-0154, NWE D Subtask Code Y99QAXSD164, Work Unit Code 07.

A project of this type requires the support and patience of many individuals in various organizations. It is not possible to acknowledge the many participants who contributed to the ultimate success of the project. Nevertheless, special thanks must go to Messrs. L. Ingram and J. Brogan of the Waterways Experiment Station; Messrs. J. Gordon and H. Jenkins of the Air Force Weapons Laboratory; Mr. J. Keefer of the Ballistics Research Laboratories; Mr. E. Martin and Dr. L. Kennedy of GE TEMPO; Dr. T. Stubbs of Physics International Company; and Mr. J. Carpenter of R & D Associates.

Agbabian Associates personnel who contributed extensively to the project were J. Malthan, Project Manager; E. Raney, Project Engineer; and R. H. Brandt, Staff Engineer. Technical editing of the final report was performed by J. Radler.

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## APPENDIX A

### MEASURED DATA AT PHYSICS INTERNATIONAL COMPANY

Table A-1 presents a summary of the data available at Physics International for HE and nuclear tests. These data are reported to be available on digital and analog magnetic tapes or on strip charts. For recommendations concerning the disposition of these data, refer to the source document.\*

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\**Feasibility of Archiving, at Agbabian Associates, The Ground Motion Data Residing at Physics International Company, DNA 3631F (San Leandro, CA: Physics International Co., 5/75).*

TABLE A-1. SUMMARY OF PI TEST EVENTS DATA

Digital Magnetic Tape						
DIAMOND MINE	DISTANT PLAIN 6	MIDI MIST	MING VASE	PRE-MINE THROW	IV-2	
DIAMOND ORE	DORSAL FIN	MINE ORE	MISTY NORTH	PRE-MINE THROW	IV-3	
DIAMOND SCULLS	FLAT TOP I	MINE UNDER	PILE DRIVER	PRE-MINE THROW	IV-4	
DIANA MIST	FLAT TOP II	MINE THROW I	PRAIRIE FLAT	PRE-MINE THROW	IV-5	
DIESEL TRAIN	FLAT TOP III	MINERAL ROCK	PRE-MINE THROW III	PRE-MINE THROW	IV-6	
DISTANT PLAIN 1A	HUDSON SEAL	MINERAL LODGE	PRE-MINE THROW IV-1	PRE-MINE THROW	IV-7	
Analog Magnetic Tape						
ALVA	DORSAL FIN	FLAT TOP III	MINT LEAF	SMALL BOY		
CYPRESS	DURVEA	HUDSON MOON	MISTY NORTH	TINY TOT		
DIAMOND DUST	FLAT TOP I	HUDSON SEAL	PILE DRIVER	RED HOT		
DOOR MIST	FLAT TOP II	MING VASE	SALMON			
Analog Strip Chart						
ANTLER	ELEPHANT 10	MOLE 300	TEA POT ESS	YUBA		
BLANCA EVANS	GNOME	MOLE 400	TUMBLER 1	TEAPOT MET		
CACTUS	HARD HAT	PRISCILLA	TUMBLER 2	JANGLE-U		
CASTLE-KOON	KOA	RAINER	TUMBLER 3	DUGWAY SERIES		
CLEARWATER	MADISON	SMALL BOY	TUMBLER 4			
DRAGON	MOLE 100	SMOKEY	UPSHOT KNOTHOLE 9			
ELEPHANT 9	MOLE 200	TAMALPAIS	UPSHOT KNOTHOLE 10			

## APPENDIX B

### DATA/70S PROGRAM DESCRIPTION

This appendix presents a description of the DATA/70S Data Base Management and Processing System at an intermediate level of detail. It is formatted for the system analyst who has a requirement to understand the design and operation of the system. A thorough dissertation on the system is presented in the DATA/70S *Reference Manual*.\*

DATA/70S is a digital computer software program that is used to organize, manage, process, analyze, summarize, and display large quantities of transient, periodic, and random time series data. The automated processing system provides a means of performing an extensive set of classical time series analysis studies without constraints on the volume of input data or the number of data manipulations required. The data management capability provides an efficient method for retrieving and processing selected channels of data from the data base, as well as an automatic capability for cataloging and saving processed data files for future use.

Included in this document are the basic data-management and processing concepts that structure the DATA/70S approach, a description of the functions of the major DATA/70S processing modules, and a discussion of the various modes of operating the system to perform the required data

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\*DATA/70S Data Base Management and Processing System: *Reference Manual*, R-3270-3515, rev. ed. (El Segundo, CA: Agabian Associates, 1975).

management and processing tasks. The actual operational use of DATA/70S is also described, including a discussion of the required computer equipment, analyst/operator/program interfaces, and special programming considerations and features of the system.

## B.1 SYSTEM DESIGN OVERVIEW

The basic problem that is solved with the aid of the DATA/70S program is to organize and analyze a set of raw data and produce concise summaries and results that will yield definitive conclusions concerning the data characteristics. The elements and characteristics of this processing task are shown in Figure B-1. The basic processing functions provided by DATA/70S are shown in Figure B-2.

The raw input data may consist of a large number of different sets of measurements from a variety of data sources and in a range of formats. To analyze the data, it is necessary to construct a data base containing the input files of data organized with identification information, to manipulate and manage the data-base, process and analyze individual data channels and combinations of data channels, save processed files in the data base, and interpret and summarize the results of the analysis. The end result of the process is a summary of valid data with a concise history of the processing steps that produced each final element. The results are most conveniently displayed by plots, which may be used for analyses and comparisons of test data.

### B.1.1 THE DATA/70S DATA BASE (MASTER FILE)

The DATA/70S data base consists of a multireel magnetic-tape library designated as the Master File. Each tape contains a tape header-label

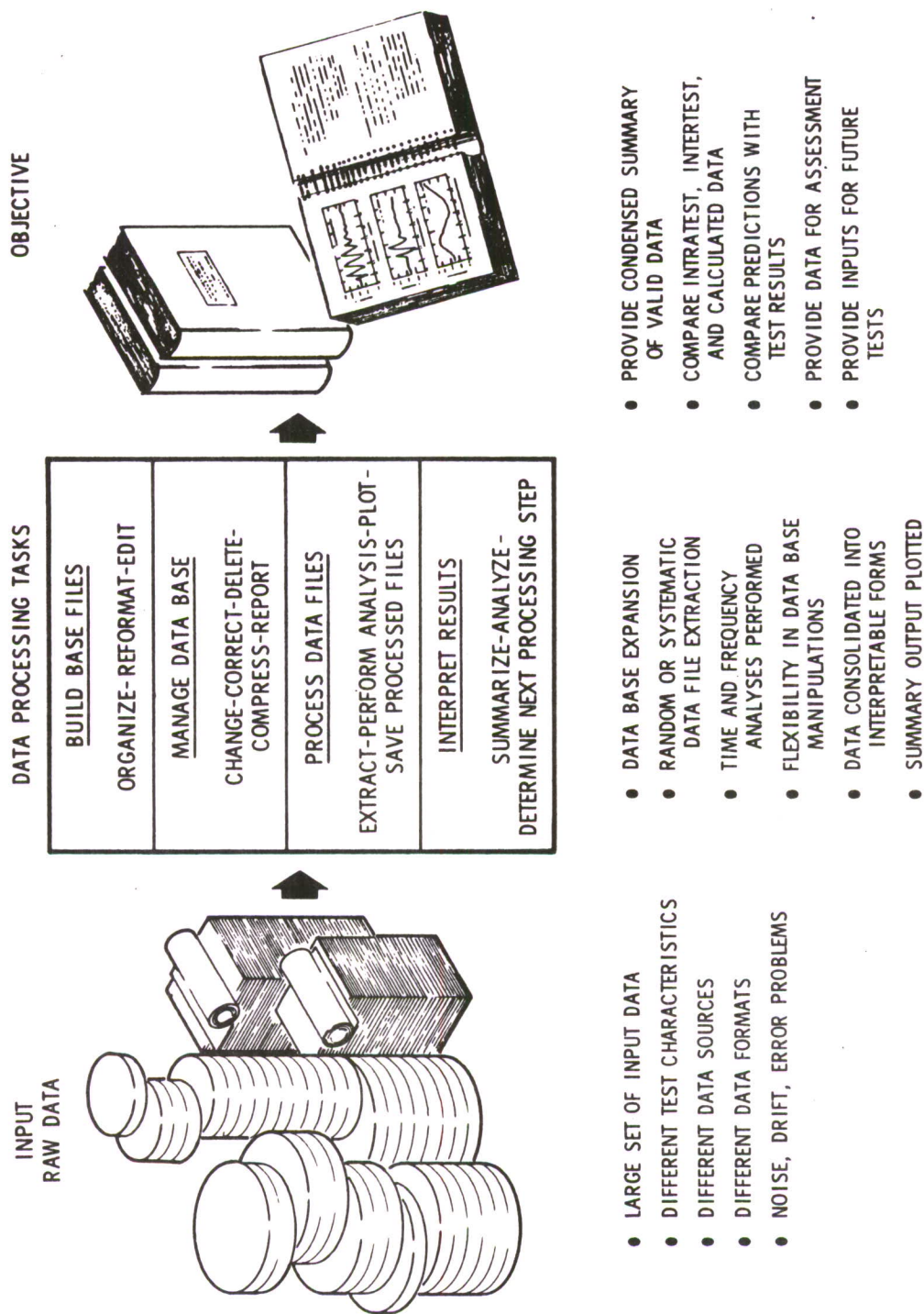


FIGURE B-1. TYPICAL ELEMENTS OF DATA SUMMARIZATION

## PREPROCESSING

- A/D conversion or digital data reformatted
- Data calibration
- Keypunch annotation

## DATA MANAGEMENT

- Build master file and directory
- Select, edit, and normalize raw data
- Maintain and update master file
  - Corrections, additions, deletions
  - Complete processing history retained
- Extract data
  - Single time-history record
  - Multiple records selected in groups by test event, and measurement type, location, and orientation
- Provide listing and location of every record on file

## DATA PROCESSING

- Scaling, time shift, integration
- Filtering and decimation
  - Highpass, lowpass, bandpass, bandreject

## DATA PROCESSING (CONTINUED)

- Detrending
  - Least squares (linear and nonlinear fit)
  - Direct subtraction of offset and drift
- Time-domain analysis
  - Autocorrelation
  - Cross-correlation
- Frequency-domain analysis
  - Fourier transform
  - Power spectral density
  - Transfer functions
- Summarization processes
  - Ensemble averaging
  - Peak envelope
  - Statistical means and deviations

## GRAPHICAL AND TABULAR OUTPUT

- Single plots
- Linear scales
- Multiple plots
- Semi log scales
- Overlay plots
- Log/log scales
- Annotation
- Autorange scale selection

FIGURE B-2. DATA/70S BASIC PROCESSING FUNCTIONS

record and multiple files, each file of which consists of a header record and multiple data records.

The tape-label record contains a user-provided data base identifier and an integer reel-sequence number. (This information is also written on the physical reel to allow for easy identification of the tape.)

Each data channel in the data base occupies one file on a Master File tape. The header record for the file contains the identification words for the data channel (channel ID) that provide the basic data-source designations (e.g., test source, location, codes, depth, etc). The header record for the data channel also includes statistical and summary information about the file, such as sampling rate, sampling start time, mean, variance, number of points, and amount of tape footage required to store the file in the Master File. When Master File data channels are processed with DATA/70S and the resultant file is entered into the data base, the header record is used to record the processing options used in creating the new file and to identify the data channel that was the source for the operation. Thus, the header record for each data channel provides a history of the action taken in producing the file.

The data records for a particular Master File entry follow the header record and contain evenly spaced (based on the sampling rate in the header), time-ordered floating-point numbers. The only restriction on the number of data points is that no file is allowed to span physical reels. Additions to the Master File library are added to the last tape; or if insufficient space is available for the entire file, a new tape is placed in the library with the next sequence number. Therefore, a particular data channel must occupy less than a full physical tape (2400-ft tapes accommodate more than two million points).

### B.1.2 THE DATA BASE INDEX (DIRECTORY)

To provide ready access to data channels in the Master File library, the DATA/70S program automatically maintains an index file designated as the Directory.

The Directory is stored on magnetic tape and copied to a direct-access device by DATA/70S for use during program execution. The Directory tape contains a header-label record that provides the corresponding data-base name and a sequential directory tape number (since a new directory is generated each time the Master File is altered). In addition, the label provides the reel number of the last Master File tape, the tape footage currently available on the last tape, and the current number of data channels in the Master File.

The Directory contains a 28-word entry for each data channel in the Master File. Directory entries are ordered by Master File element number, which is a sequential integer assigned when the data channel is added to the library. Hence, the first Directory entry is for Master File element No. 1, which is the first data channel on Master File tape No. 1. Each indexing entry in the Directory contains the channel ID, the location of the channel in the Master File (reel number, file number on the reel, position on the tape in terms of tape footage), a flag indicating whether the file is active or inactive, and the Master File entry number of the parent file if the channel was created by processing an existing Master File data channel.

Hence, the Directory may be used to determine the location in the Master File library of any particular channel ID, to provide a summary of the contents of the Master File library, and to indicate to DATA/70S where to begin adding new channels to the library.

### B.1.3 CLASSIFIED DATA BASES (WHERE APPLICABLE)

A special capability is available in the DATA/70S program for handling classified data. The system maintains the Master File in a declassified form by normalizing the data points. To normalize data, all data points in a given data channel are divided by the maximum of the absolute values of all data amplitudes in the channel or by any arbitrary value selected by the user. When such normalized values are written in, the Master File then becomes unclassified, assuming that no classified information is contained in the header records. The classified conversion factor is saved in a separate Classified Directory and is applied as a multiplicative factor to each data point in the channel when the classified values are required during DATA/70S processing. In order to allow completely unclassified executions of DATA/70S, the system maintains two Directory tapes, a classified Directory tape containing the normalizing factors and an unclassified Directory without the factors. Unclassified computer runs may be made whenever normalized data are acceptable; and on the next classified DATA/70S run, DATA/70S will automatically construct a new classified Directory that reflects any changes made to the Master File since the previous classified execution.

A summary of the Master File/Directory features are presented in Table B-1.

### B.1.4 THE DATA/70S PROGRAM

As shown in Figure B-1, the major data processing tasks include data-base construction, the data-base management, and data-file processing. The DATA/70S program is constructed to perform these tasks through the execution of a modularly designed, functionally oriented, unified software system.

TABLE B-1. FEATURES OF THE DIRECTORY AND MASTER FILE

DIRECTORY	MASTER FILE
Disk or Tape File	Multireel Tape Library
<ul style="list-style-type: none"> <li>● Provides a 28-word format for each data channel in the Master File</li> <li>● Locates the data channel in the Master File Library</li> <li>● Provides the data normalizing factor</li> <li>● Provides the Master File entry number of the parent data channel for new data channels generated by processing</li> <li>● Indicates whether the data channel has been deactivated for future automatic processing</li> </ul>	<ul style="list-style-type: none"> <li>● Single tape file for each channel of data</li> <li>● Fixed format header record containing alphanumeric, integer, and floating point information for the data channel</li> <li>● Multirecord normalized data values in floating-point format</li> <li>● No confining restrictions on number or length of data channels in the Master File Library</li> <li>● Provides data channel identification, summary statistics, and historical processing information</li> </ul>

Basic modules are provided to--

- a. Organize, reformat, and edit raw input data and build corresponding Master File and Directory entries;
- b. Perform basic data-base management tasks, i.e., modify selected Master File header information, deactivate data channels that are no longer needed, print selected Master File or Directory information, and compress the entire Master File library by copying all the tapes to a new tape library and deleting unneeded files; and

- c. Process data files by extracting requested channels from the Master File library (selected by channel ID or Master File entry number), performing selected time series analyses on single or multiple data channels, plotting the basic and/or processed data, and storing any desired processed files in the Master File library.

The basic processing modules in DATA/70S are controlled by a single executive program that interprets user input cards and automatically performs the options required to accomplish the requested tasks. The program issues all required operator instructions (e.g., tape-mount requests) through the computer console.

## B.2. DATA/70S FUNCTIONAL MODULES

The DATA/70S program is basically organized into five major processing modules and the utility service modules, as shown in Figure B-3. The operation of these modules is controlled by the DATA/70S Executive, based on the user's requests.

### B.2.1 INPUT DATA CONVERSION MODULE (EDITOR)

The basic function of the Input Data Conversion Module (EDITOR) is to convert raw input data into Master File format. EDITOR accepts binary-coded decimal (BCD) and binary input tapes in several different formats. EDITOR is structured for modification to accommodate raw data tapes in other formats.

EDITOR requires two control-card decks as input. One set of cards controls the processing of the series of input tapes, indicating which files of

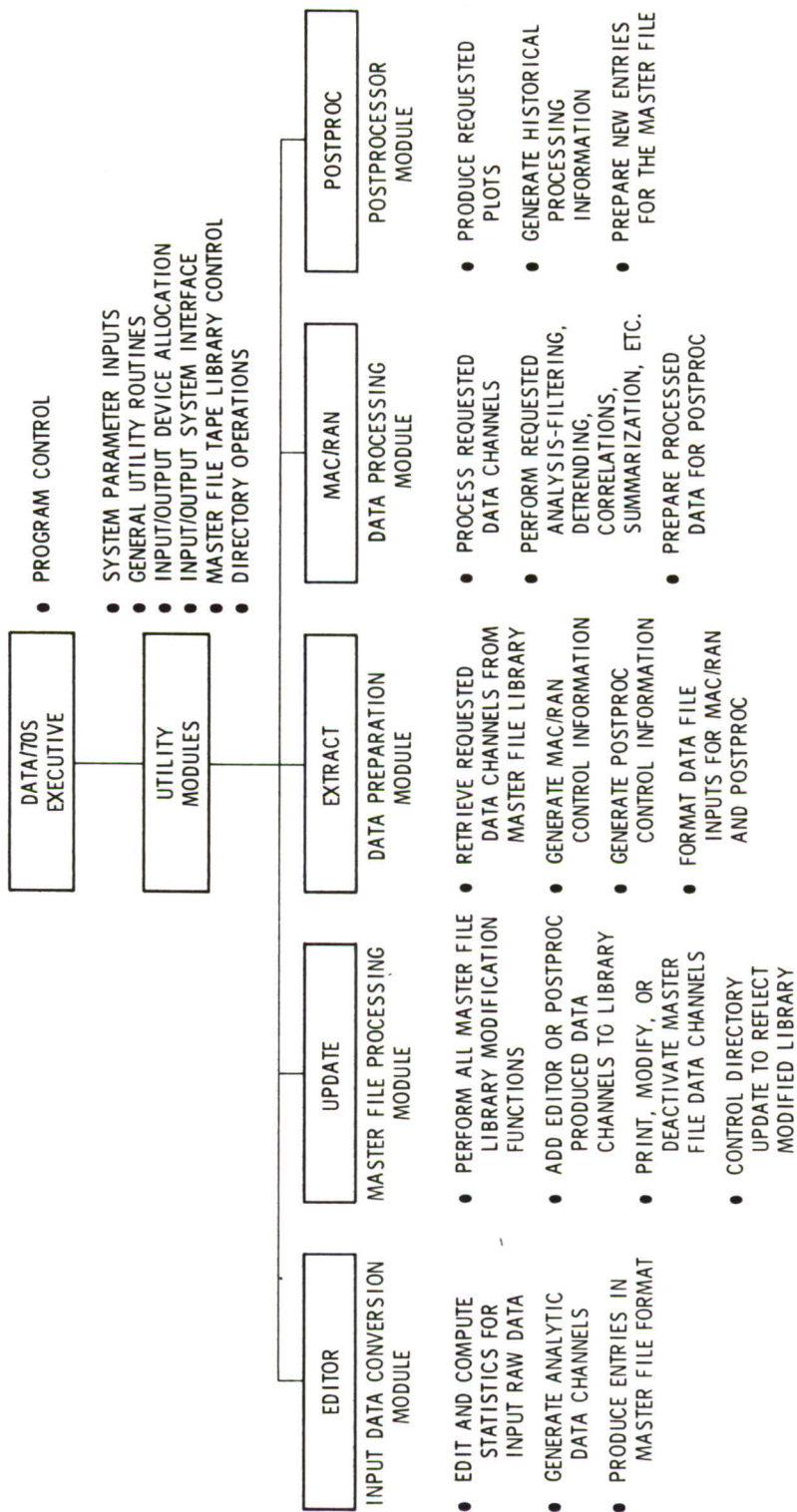


FIGURE B-3. DATA/70S MAJOR MODULE SUMMARY

input data are to be processed or skipped on each tape and the configuration of the input data files on the physical tape reels. Also, the sampling rate may be set through this card deck for each input data channel if it is not available on the tape. The tape file-control logic is independent of the particular input tape format and does not generally require modification when new input tape format capabilities are added to the EDITOR program.

The second set of EDITOR control cards provides annotation data for the output Master File header record for each channel of data to be added to the Master File. Two cards are required for each data channel and provide channel ID information, scaling-factor codes (convert feet to inches by multiplying by 12.0, etc.), and additional descriptive information about the data channel, which is passed to the output header record. An additional field is provided on the header input cards that allows an optional check of a 12-character field punched on the card against a specified field on the input data tape to ensure proper positioning of the input tape. This field is usually activated on selected input files to guard against errors in the input control decks.

The DATA/70S input/output system allows EDITOR to read raw input data tapes and to check each required character for validity during the conversion to floating point format. Out-of-tolerance data points may be rejected and replaced by interpolating new values based on the running mean of the data or by setting the bad values to zero (controlled by user request). This feature allows EDITOR to read damaged or worn field test tapes or to recognize and reject wild-points data.

EDITOR accumulates statistics for each processed data file, including minimum and maximum data values, value of time at the minimum and maximum,

total number of data points, and data mean and standard deviation. These values are passed to the Master File in the output header record.

The output of EDITOR consists of a Master File header record and multiple data records for each processed data channel (based on one input tape file). For each input tape file processed, EDITOR prints any header information provided on the input tape for the data channel. The input header cards used in each case to build the output Master File header are printed along with the above information.

In the DATA/70S program, EDITOR interfaces only with the UPDATE module, which adds the EDITOR-generated Master File entries to the data base.

#### B.2.2 MASTER FILE PROCESSING MODULE (UPDATE)

The Master File Processing Module (UPDATE) performs all modifications to the Master File Library. The module has five basic modes of operation:

- a. EDITOR/UPDATE mode: UPDATE normalizes the data channels produced by the EDITOR module and adds the resultant to the library.
- b. POSTPROC/UPDATE mode: UPDATE merges the header tape and data tape information from POSTPROC and adds the resultant processed data channels to the Master File library.
- c. Pure UPDATE mode: Based on user requests, UPDATE prints selected Master File entries; performs modifications to the headers of requested entries, deactivates the entry through the

Directory, and adds the resultant to the Master File; modifies the header, time-shifts the data for requested entries, and adds the result to the Master File; or deactivates entries from the Master File through the Directory.

- d. Clean-up mode: UPDATE reads the entire Master File library and generates a new compressed tape library. The disposition of each file in this process is controlled by the corresponding Directory entry or by input data cards.
- e. Log/Print mode: UPDATE reads and prints the entire Master File library. The information printed for each file is controlled by the corresponding Directory entry or input data cards.

Any changes to the Master File library require corresponding modifications to the system Directory. This is accomplished by UPDATE through the Add/Delete tape, which provides the interface with the Directory Operation Module. The Add/Delete tape contains a complete Directory format entry for each data channel that is deactivated or added to the library. The Directory Operations Module uses this interface tape to add the new entries to the Directory and to set the delete flag for those entries specified as deactivated. A deactivated data channel still exists in the Master File library, but the channel ID will not be selected for automatic processing through the Data Preparation Module (EXTRACT). In addition to the Add/Delete tape, UPDATE will, on option, punch an Add/Delete card deck that may be saved and used as a backup means of regenerating the Directory.

UPDATE operational modes (a) and (b) above are straightforward and consist of merely adding the new data channels to the library and creating the

corresponding Directory entries. UPDATE adds new files to the last reel in the Master File library if there is sufficient space on the tape. Otherwise, a new tape is added to the library and assigned the next sequential reel number.

UPDATE modes (d) and (e) are specialized features for automatically compressing or printing an entire Master File library. In the Clean-up mode, the deactivated files are typically removed from the library. The option is provided to override the automatic selection process by requesting any particular file to be saved or deleted. Also, the header record for a particular data channel may be saved with the data records deleted. This is useful if the data are no longer needed, but the header information serves as a historical processing summary. In the Log/Print mode, UPDATE prints the header record and data values (at an input print sampling rate) for active files and only the header information for deactivated files. As before, this automatic print selection process may be overridden for specific files through card inputs.

The data base management tasks performed by UPDATE in mode (c) are controlled by a user request deck that specifies the data channels to be processed (by channel ID or Master File entry number) and the operations to be performed on the channels. If the header modification option is requested, the original file is deactivated, the modifications specified on the input cards are performed, and the new file is added to the library.

The data-shift option allows zeros to be added or data to be truncated at the beginning or end of a data channel. In addition, the start time of the data channel may be adjusted and modifications made to the header record. In this case, the original channel is not deactivated, but the new channel is added to the library.

In addition to the Add/Delete tape interface with the Directory Operations Module, UPDATE also uses this module to locate and schedule Master File tape requests for the desired Master File data channels.

UPDATE formats and prints the Master File header record information for each data channel added to the Master File. In addition, the data values may be printed at a specified sampling rate. This information may be classified or declassified (normalized) on request.

### B.2.3 DATA PREPARATION MODULE (EXTRACT)

The Data Preparation Module (EXTRACT) extracts requested data channels from the Master File library and prepares the input required for the data analysis modules (MAC/RAN and POSTPROC) to perform the requested processing. The process request deck consists of a set of process definition cards followed by the channel IDs of the data channels on which the requested analysis is to be performed. As many groups of process request cards and associated channel IDs as desired may be input to a given EXTRACT execution.

A card-image file is generated by EXTRACT on an intermediate direct-access device to define the operations to be performed on the data channels by the MAC/RAN Module. These MAC/RAN control cards may be punched by DATA/70S on request.

EXTRACT uses the Directory Utility Module to locate and schedule Master File tape requests for the desired Master File data channels. Data files may be requested by specific channel ID, or a set of channel IDs may be requested with specified ID fields ignored (i.e., groups of data channels may be requested using the asterisk notation for each of the channels desired). The

data files to be processed are read from the Master File tapes in the sequence requested and reformatted for use in MAC/RAN or POSTPROC. The interface tape format includes MAC/RAN control words and data point pairs (time and associated amplitude value). On classified runs, EXTRACT converts the amplitude values by multiplying each point by the classified conversion factor supplied by the Directory Operations Module.

In addition to the MAC/RAN control card file, EXTRACT produces three types of output tapes: the MAC/RAN interface tape containing data channels to be processed by MAC/RAN; the POSTPROC interface tape containing data channels bypassing MAC/RAN, to be processed directly by POSTPROC; and the POSTPROC header tape, which includes the original input-request card images and the Master File header record associated with each processed data channel.

EXTRACT printout provides a summary of the requested processing options and channel IDs and a history of the generated MAC/RAN control-card images.

#### B.2.4 DATA PROCESSING MODULE (MAC/RAN)

The Data Processing Module (MAC/RAN) performs the basic time series analysis functions for the DATA/70S program. The input to MAC/RAN is provided by the EXTRACT Module, and includes control-card images describing the requested analysis options and the original data channel to be processed.

MAC/RAN writes the processed data files on tape for the POSTPROC module, which plots the resultant files and/or formats the files for storing in

the data base. MAC/RAN also writes a file on direct access, which contains statistical information about each data channel. This information is used by POSTPROC as well as internally in MAC/RAN, and may be punched on request to ensure restart capability.

MAC/RAN, a self-contained module within DATA/70S, contains its own executive for data-flow control and PRINT and PLOT processors for printing and plotting options independent of the capabilities in the DATA/70S POSTPROC Module. The EXEC Module operates independently of the DATA/70S user; the PRINT and PLOT Module is available to the user on command. The data processing modules in MAC/RAN include the following:

Executive	Printer and Plotter Output
Calibration	Time and Frequency Analysis
Data Preparation	Linear Systems Analysis
Amplitude Statistics	Ensemble Averaging Technique
Fourier Transform	Shock Spectrum
Power Spectral Density	One-Third Octave
Out-of-Core Power Spectral Density	Phase Lock Loop Tracking Filter
Plugboard Simulation	Preloading
Convolution and Filtering	Time and Frequency
Card to Tape	Convolution and Detection

A description of each MAC/RAN Module is described in the following sections. A more detailed description is presented in the MAC/RAN

*Reference Manual*.<sup>\*</sup>

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<sup>\*</sup>*Reference Manual, MAC/RAN III*, R. K. Otnes, ed. (El Segundo, CA: Agbabian Associates, 1973).

#### B.2.4.1 Executive Processor (EXEC)

The control portion of the MAC/RAN system is the Executive Processor. The EXEC controls the overall operation of the system through control cards that are supplied as input for any given job.

#### B.2.4.2 Calibration Processor (CALIB)

The Calibration Processor provides the capability to convert raw digitized data from "counts" to meaningful engineering units. It also permits adjustments to be made for offsets and nonlinearities introduced into the data by the collecting and recording devices.

#### B.2.4.3 Data Preparation Processor (PREP)

The Data Preparation Processor performs four functions usually encountered after any required calibration: wild-point editing, trend removal, numerical filtering, and decimation.

#### B.2.4.4 Amplitude Statistics Processor (AMSTAT)

The Amplitude Statistics Processor computes the sample probability distribution function and performs a chi-square goodness-of-fit test for normality (Gaussianity). In addition, it can compute the sample mean, sample variance, sample standard deviation, and third and fourth sample moments for each time history.

#### B.2.4.5 Fourier Transform Processor (FOUR)

The Fourier Transform Processor computes the Fourier transform of real time-history data or the inverse Fourier transform of complex

frequency data. Up to 12 time histories or 12 complex frequency functions may be processed at one time. If possible, computing is done in core; if not, the transform is computed using auxiliary storage.

#### B.2.4.6 Power Spectral Density Processor (PSD)

This processor employs several implementations of the fast Fourier transform (FFT) to compute power spectral densities, cross-spectral densities, simple transfer functions, and coherence functions. Several spectral windows are available. Analysis procedures to attain specified resolution bandwidths may be selected from several schemes.

#### B.2.4.7 Out-of-Core Power Spectral Density Processor (BIGPSD)

The out-of-core power spectral density is employed in conjunction with the FOUR Processor to compute power spectral densities in certain special cases where the PSD Processor would not be appropriate. PSD can process out-of-core data, but it divides the data into segments. This induces a window larger than that occurring when the whole series is used, thus resulting in more leakage.

#### B.2.4.8 Plugboard Simulation Processor (PLUG)

The purpose of the Plugboard Simulation Processor is to simulate a large variety of analog-type calculations with their discrete equivalent, and to allow the user to perform a large variety of operations upon the data. PLUG manipulations fall into seven categories: arithmetic operations, such as addition, subtraction, etc.; elementary real functions, such as log, exponential, sin, cos, arctan, etc.; complex arithmetic and functions; digital filtering; data

generation including time, frequency, and random data in either uniform or Gaussian distribution; and testing and transfer operations.

#### B.2.4.9 Convolution and Filtering Processor (CONFIL)

This processor uses implementations of the fast Fourier transform algorithm to perform convolution correlation and filtering. Several computation options are available in CONFIL. When filtering is required, either the unit impulse response  $h(t)$  or the transfer function  $H(f)$  may be utilized. It is also possible to obtain the product of a transfer function with the power spectral density  $G_x(f)$  of a time series. This product corresponds to the PSD of the filtered time series. Convolution, correlation, and filtering options may be performed on time series of unlimited length.

#### B.2.4.10 Card to Tape Processor (CTAPE)

The Card to Tape Processor operates in three modes. In the first mode, it reads data punched in the MAC/RAN standard control card format (SCC) from the standard input tape and writes the data on tape in the MAC/RAN standard intermediate data tape (SIDU) format; in the second, it reads a format statement, and then reads punched cards in that format and outputs the data in the SIDU format; in the third mode, the process is reversed: the processor reads in a MAC/RAN SIDU and punches those data out on cards in the standard card format. Channel directory cards are generated in both modes one and two.

#### B.2.4.11 Printer and Plotter Output Processor (PLOT)

The Printer and Plotter Output Processor provides a convenient means for listing and/or plotting output from any data tape in MAC/RAN. Any

function or combination of functions from a file computed with the MAC/RAN system and written on tape may be saved and later printed or plotted by the Printer and Plotter Output Processor.

#### B.2.4.12 Time and Frequency Analysis Processor (SPEC)

The basic outputs of the Time and Frequency Analysis Processor are auto- and cross-correlation functions, and power and cross-spectral density functions computed from a pair of time histories. The processor can simultaneously analyze two sequences of unlimited sample lengths. The classical Blackman-Tukey computation procedure is implemented in this processor. That is, the correlation function is first computed, followed by a Fourier transformation to obtain the spectral density function.

#### B.2.4.13 Linear Systems Analysis Processor (TRANS)

The Linear Systems Analysis Processor operates on spectral density matrices from order 2 up to a maximum of 25. Frequency response functions, coherence functions (ordinary, multiple, and partial) and associated confidence limits are computed for single-input/single-output and for multiple-input/single-output linear systems.

#### B.2.4.14 Ensemble Averaging Technique Processor (ENSAV)

The Ensemble Averaging Processor accepts a set of up to 24 time histories and produces as output a file of ensemble information. The file contains the mean, mean square, sum, sum of squares, and the variance. Each of the time histories may be time-advanced, scale-aligned, and weighted, prior to the averaging process. These transformations provide the alignment and zero adjustment that may be required.

#### B.2.4.15 Shock Spectrum Processor (SHOCKS)

SHOCKS calculates the peak responses of a set of second-order mechanical systems (each such system tuned to a different natural frequency) to the shock produced as a function of their natural frequencies. The response history is broken into primary and residual time periods from which five peak responses are calculated: primary positive, primary negative, residual positive, residual negative, and the maximax.

#### B.2.4.16 One-Third Octave Processor (THROCT)

One-Third Octave Analysis employs proportional, rather than constant, bandwidth frequency analysis. This is accomplished by using a series of band-pass filters covering the various frequency ranges. A variety of computational options are available within this processor. These options include RMS time history, one-third octave filtered time history and power, and RMS spectrum and spectral density functions.

#### B.2.4.17 Phase Lock Loop Tracking Filter (PHLOOP)

The Phase Lock Loop Tracking Filter Processor tracks a function, basically sinusoidal, that is varying with time. Based on the tracked frequency, PHLOOP may optionally track a second function and compute coherence between the two functions. Harmonics of the second function may also be tracked.

#### B.2.4.18 Preloading Processor (PRELOD)

This processor is used to preload a scratch storage unit with a set of data. It is to be used in conjunction with the PREP and CONFIL Processors.

#### B.2.4.19 Time and Frequency Processor (TRIDEE)

The Time and Frequency Processor computes the minimum bandwidth Power Spectral Density of adjacent segments of a time history, and plots these frequency segments in an overlapping manner, so that the result is effectively a three-dimensional plot with power as the dependent variable, and time and frequency as the independent variables.

#### B.2.4.20 Convolution and Detection Processor (CONDET)

The Convolution and Detection Processor detects repetitive events and computes their average and variance after they are detected. The detection is done through a convolutional procedure (matched filter) whereby the entire data sequence is convolved with a mask function. If the result of the convolving process falls within the specified limits, a detection is assumed to have occurred.

#### B.2.5 POSTPROCESSOR MODULE (POSTPROC)

The Postprocessor Module (POSTPROC) accepts output from the Data Preparation Module (EXTRACT) and the Data Processing Module (MAC/RAN), and provides a means for output file (i.e., data channel) disposition. The main functions of POSTPROC include:

- Identification of the output data channel
- Updating of the header to retain the processing history and the process parameters
- Updating of the basic statistical parameters
- Provision of user-requested plotted, printed, and punched output

- Reformatting of user-selected data channels to be returned and saved in the Master File

POSTPROC accepts a header tape provided by EXTRACT, which contains groups of process definition cards, channel ID cards, and the Master File headers of each ID to be processed. The header tape is interrogated by POSTPROC to identify the processes performed on each data channel and to determine the disposition of the output data channels. The processed data channels are provided to POSTPROC on MAC/RAN output-data tapes and an EXTRACT bypass tape. For each ID with a process group string, POSTPROC scans the process definition cards to determine the number and location of the output data channels. The original Master File header is updated with statistical information obtained from the MAC/RAN out-put. In addition, POSTPROC updates the ID and header to denote processed data (i. e. , integrated velocity channels become displacement channels, etc.) the processes performed, the process parameters used, and the input (or source) data channel. Based on disposition cards, each output data channel and its updated header is plotted, printed, punched, returned to the Master File, or destroyed.

The basic plot format allows the user to display from one to four graphs per page, with multiple data curves per graph. Linear, semilog, and log/log graphs are available and can be intermixed on the same page. Upon user request, graphs can share common x-axes and common y-axes, and curves can be plotted over a portion of their entire range. In addition, each curve is provided with annotation that shows the updated ID, key source and statistical data, process history, and the process parameters. Output data

channels that are to be returned to the Master File are written to tape for the UPDATE module.

## B.2.6 UTILITY MODULES

The utility DATA/70S modules provide those capabilities required for the overall operation of the system. These include general service and input/output functions, presetting system-control parameters and processing input-system control cards, assigning logical units for each module, and controlling the input of the Master File tapes.

### B.2.6.1 General Service Routines

Several subroutines in the DATA/70S program perform general processing and utility tasks, and are used by more than one module. Examples of such routines are a timing routine, the general display package that controls all console messages, and tape label processing routines.

### B.2.6.2 System Input Processor Module

The System Input Processor Module is executed at the beginning of each DATA/70S run to set up the run itinerary and to set all system-control parameters, which are maintained in a common core area and are available to all processing modules. The Input Processor presets the control parameters and then reads input data cards to override the nominal values. Examples of system-control parameters are record lengths for various data files, number of characters per computer word for the computer system in use, maximum

number of feet available on Master File tapes, sequence number of the latest Directory tape, and various print and punch option requests. More than 125 control parameters are used in the DATA/70S program.

#### B.2.6.3 Input/Output Module

The Input/Output Module contains all the routines used for non-FORTRAN I/O within the DATA/70S program. Capabilities are provided for block read and write, automatic double-buffering of reads and writes, rewind, record skip forward or backward, file skip forward or backward, write file mark, and tape unload. On computer systems with drum devices rather than disks, a drum-positioning feature is also provided. The major subroutine that interfaces with the computer operating system I/O routines is machine dependent and is generally written in assembly language.

#### B.2.6.4 Input/Output Device-Allocation Module

The DATA/70S Program is a combination of modular subsystems that communicate with each other and with the data base, primarily through tape and direct-access files. The Input/Output Device Allocation Module coordinates and optimizes logical unit assignments throughout DATA/70S. The data transmission problems that are handled through the Device Allocation Module include adaptation of mixed-width tape systems, allocation of logical units to direct-access devices, and assignment of available tape drives.

In a fixed channel system, simultaneous I/O operations must be distributed as evenly as possible among the data transmission channels. Overall operating time is greatly decreased in runs requiring a large amount of tape

handling by optimizing the order and location of tape mounts. Scratch tapes remaining from a previous function may be left mounted as output tapes, and new tape mounts should be made on open drives or drives most likely to have the previous tape dismounted. Tapes that are to be used by some later module should remain mounted, if possible. In the case of mixed-width tape systems, any remount must be on a similar device. Multireel files must also be considered, since several or all of the reels still mounted at the end of module execution may be retained in the next module configuration. Also, some files in DATA/70S may be assigned to direct-access units or tape units, depending on the availability of tape drives and the type of computer in use.

In general, all assignment and logical unit information is determined for a module just prior to its execution. These requirements are satisfied by the Device Allocation Module according to the individual needs of the module and in conjunction with the other modules used in the run.

#### B.2.6.5 Master File Tape Handling Module

The Master File Tape Handling Module controls the input of Master File tapes for the UPDATE and EXTRACT Modules. The Tape Handling Module requires an array containing the tape and file numbers and tape footage for each file requested. This array is generated by the user modules based on information provided by the Directory Operations Module, which interfaces directly with UPDATE and EXTRACT.

The Tape Handling Module may use up to five tape drives for input. Mount messages are displayed that give the required Master File tape numbers. The tapes may be mounted on any available input drive. The user subsystem

calls the Tape Handling Module when it is ready to process the next requested input data channel. The Tape Handling Module returns the logical unit containing the file after the tape has been properly positioned. On each call the Tape Handling Module checks the status of all the input tape drives. Wait time is minimized by issuing tape positioning commands (file skips, rewinds, unloads) based on calculation of the time required to complete the previous operation on the unit. The use of this timing technique ensures that no wait will occur unless all of the input tape drives are operating or all of the required positioning commands for processing have been issued.

#### B.2.6.6 Directory Operation Module

The Directory Operations Module performs all functions associated with printing, updating, and locating Master File entries from the system's Directory tapes. The Directory Operations Module operates in three basic modes:

- a. Directory Initialization Mode
- b. Directory Update Mode
- c. Directory Scheduling Mode

The Directory Initialization function is performed immediately prior to the execution of the first subsystem that requires the Directory.

The basic functions of the Directory Initialization mode of operation are to--

- a. Request Directory tape mounts and verify the validity of the input Directory.

- b. Copy the latest Directory to direct access for later subsystems.
- c. Generate a Directory tape from input cards on request (backup mode of operation).
- d. On classified runs, update the classified Directory to the level of the input unclassified Directory.

The Directory Update function is automatically performed by the DATA/70S Executive at the conclusion of any run that requires the Directory. In addition, the Directory Update function may be executed in the stand-alone mode to perform utility Directory functions.

The basic functions of the Directory Update subsystem are to--

- a. Generate an Add/Delete tape from input cards, if requested (backup mode of operation).
- b. Process the Add/Delete tape generated by the UPDATE subsystem or from input cards and perform the requested modifications to the system Directories.
- c. Build the final output Directories.
- d. Print the latest Directory in sequential order as entered on the Master File or in ID-sorted order, and punch the Directory on cards by request.

On an unclassified run, a new unclassified Directory tape will be generated if an Add/Delete tape or Add/Delete cards are input. The delete

flag will be set for those entries specified for deactivation and the new entries will be added to the end of the Directory. The newly deleted entries and the added entries are flagged on the output unclassified Directory as updated entries. This allows the Directory Initialization function to build a corresponding classified Directory tape on the next classified run of DATA/70S.

On a classified run, new classified and unclassified Directory tapes will be generated if an Add/Delete tape or Add/Delete cards are input, or if the Directory Initialization function generated a new classified Directory in the run.

The Directory Scheduling function is called by the UPDATE and EXTRACT Modules to determine the positions in the Master File library of the entries requested for processing. The entire Directory entry for each scheduled channel ID is returned to the calling program. The information of particular interest is the Master File tape number, file number on the tape, and tape footage to the file. The calling module extracts this information from the interface array and builds an array to be used by the Master File Tape Handling Module in mounting and positioning the required tapes.

The Directory Scheduling Module has two modes of operation: standard and span scheduling. In the standard mode, used by both UPDATE and EXTRACT, the calling program provides a channel ID or Master File entry number in the interface array for each Master File entry to be processed. In the span scheduling mode used by EXTRACT, a basic channel ID is provided with one or more of the ID subfields indicated as arbitrary. The Directory Scheduling Module schedules any channel ID in the Directory for which the fixed subfields match.

### B.3 DATA/70S OPERATIONAL MODES

The flow of data through the major DATA/70S processing modules is shown in Figure B-4. This flow of data is accomplished through three principal modes of operation of DATA/70S:

- a. Raw Input Data Mode
- b. Processing Mode
- c. Master File Management Mode

DATA/70S operates in several additional modes to perform auxiliary data management functions such as Directory utility work, Master File clean-up, or Master File log/print. In addition, any of the Data/70S modules can be executed individually. The majority of DATA/70S executions, however, are in one of the three principal operation modes.

The Raw Input Data Mode is illustrated in Figure B-5. In this mode, the EDITOR Module is called to process raw input data, and the UPDATE Module is used to add the resultant entries to the Master File and to control the Directory update function.

The Processing mode is illustrated in Figure B-6. In this mode, EXTRACT is called to build the interface files for the requested data channels to be processed. If any of the channels are to undergo any of the DATA/70S time series analysis processes, MAC/RAN is called. If plotting or saving of processed or basic data is requested, POSTPROC is called; and if new files are to be stored in the data base, UPDATE is executed.

The Master File Management mode is illustrated in Figure B-7. The only major module required in this mode of operation is the UPDATE Module,

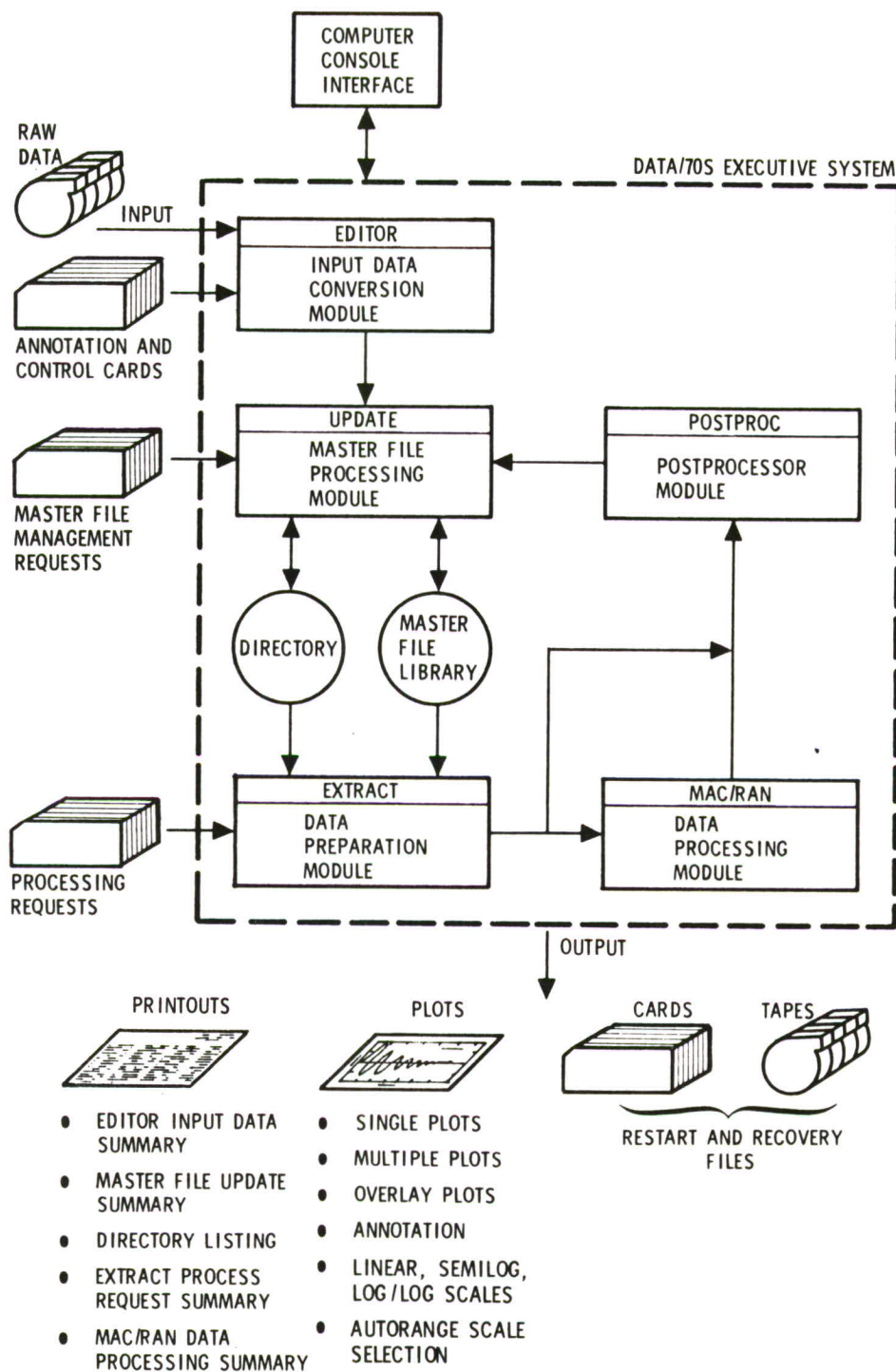


FIGURE B-4. DATA/70S PROCESSING FLOW

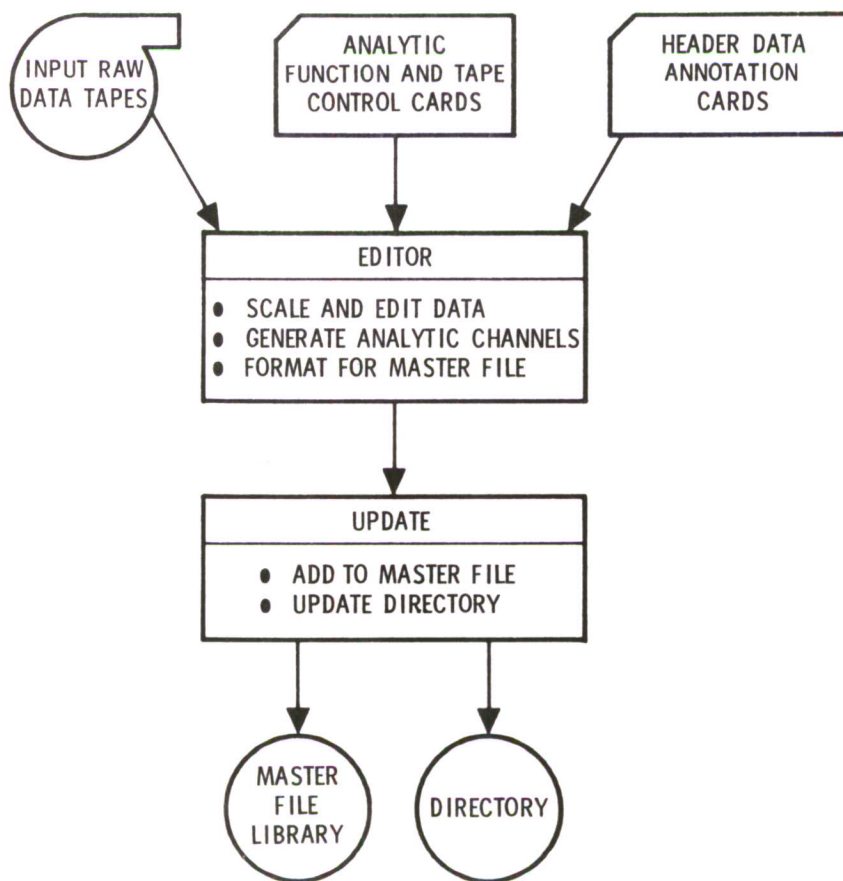


FIGURE B-5. INPUT MODE, ADDING NEW DATA THROUGH DATA/70S

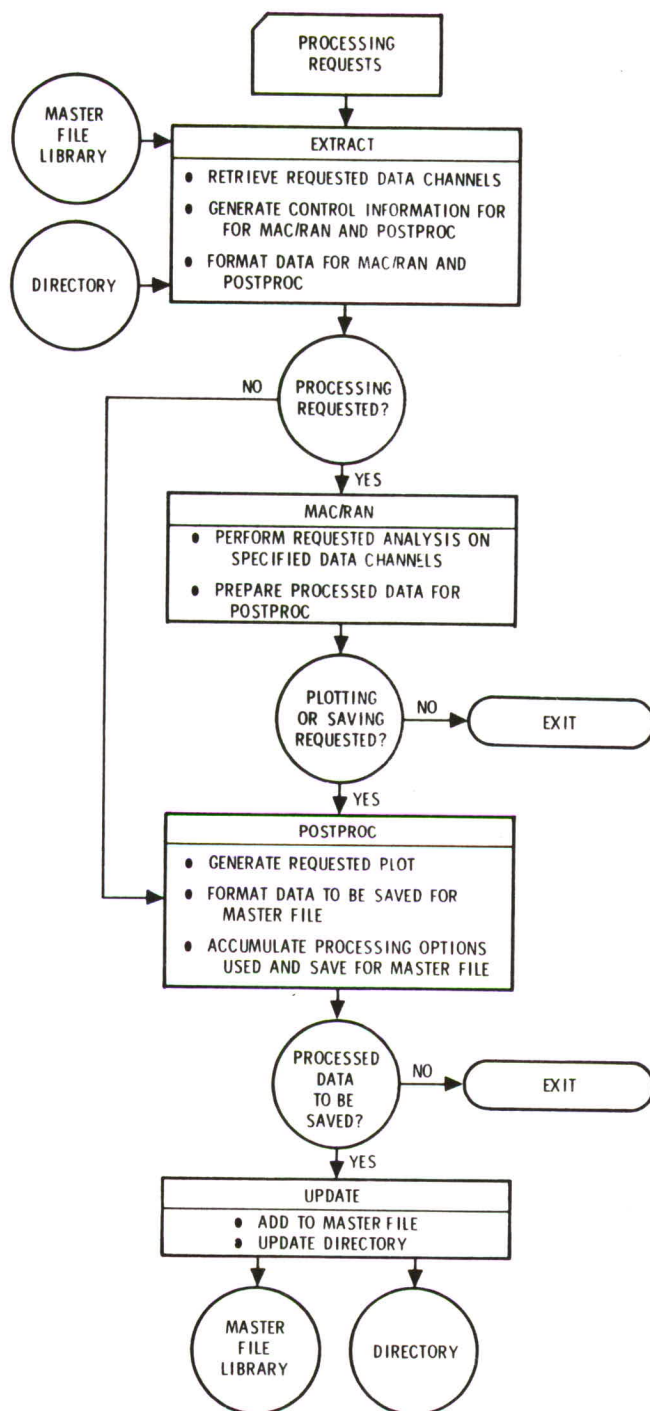


FIGURE B-6. PROCESSING MODE, PROCESSING DATA THROUGH DATA/70S

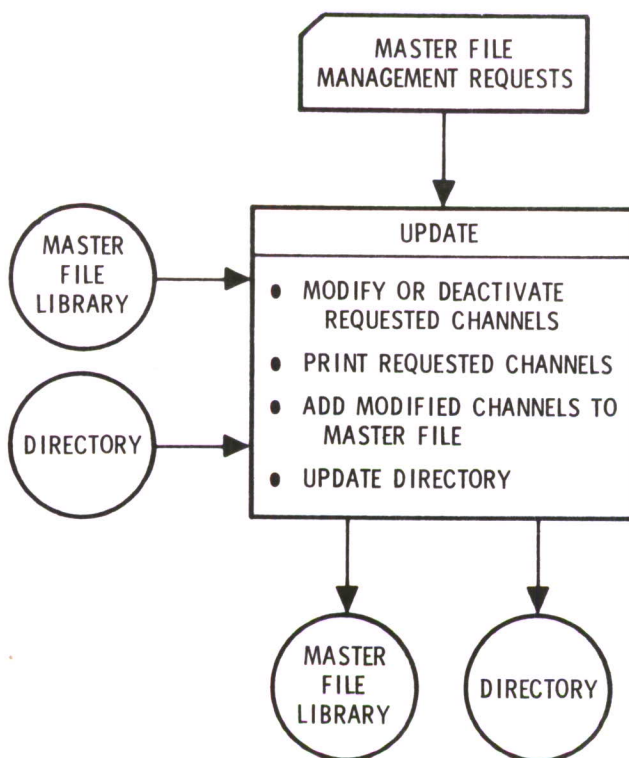


FIGURE B-7. MASTER FILE MANAGEMENT MODE, MANAGING THE MASTER FILE THROUGH DATA/70S

which performs the desired Master File data-channel printouts, modifications, or deactivations; adds modified data channels to the Master File; and controls the updating of the Directory tape.

#### B.4 THE COMPUTERIZED SYSTEM

The DATA/70S program is primarily written in the FORTRAN language and consists of more than 35,000 source cards. The program was designed and implemented to be computer independent except for some selected subroutines where consideration for efficiency requires special machine-dependent coding. The program is currently operational on the UNIVAC 1108 and CDC 6600 computer systems and requires 52,000<sub>10</sub> words of core storage on the 1108. DATA/70S is organized into nine overlays, which are called as required by the DATA/70S Executive. These nine overlays correspond to the five major modules (EDITOR, UPDATE, EXTRACT, MAC/RAN and POSTPROC), the two major Directory Operations Module functions (Directory Initialization and Directory Update), the System Input Processor Module and the Input/Output Device Allocation Module. The general utility service subroutines and the Input/Output Module are always core resident along with the DATA/70S Executive routine. The Directory Scheduling function and Master File Tape Handling Module are in core with UPDATE or EXTRACT. An overview of the DATA/70S overlay structure is shown in Figure B-8 with a given branch of the "tree" representing a set of programs that may be in core together.

The control cards required to execute DATA/70S (not including the individual-module data decks) specify the operational mode to be run, the sequence number of the current Directory tape, and data cards for any changes

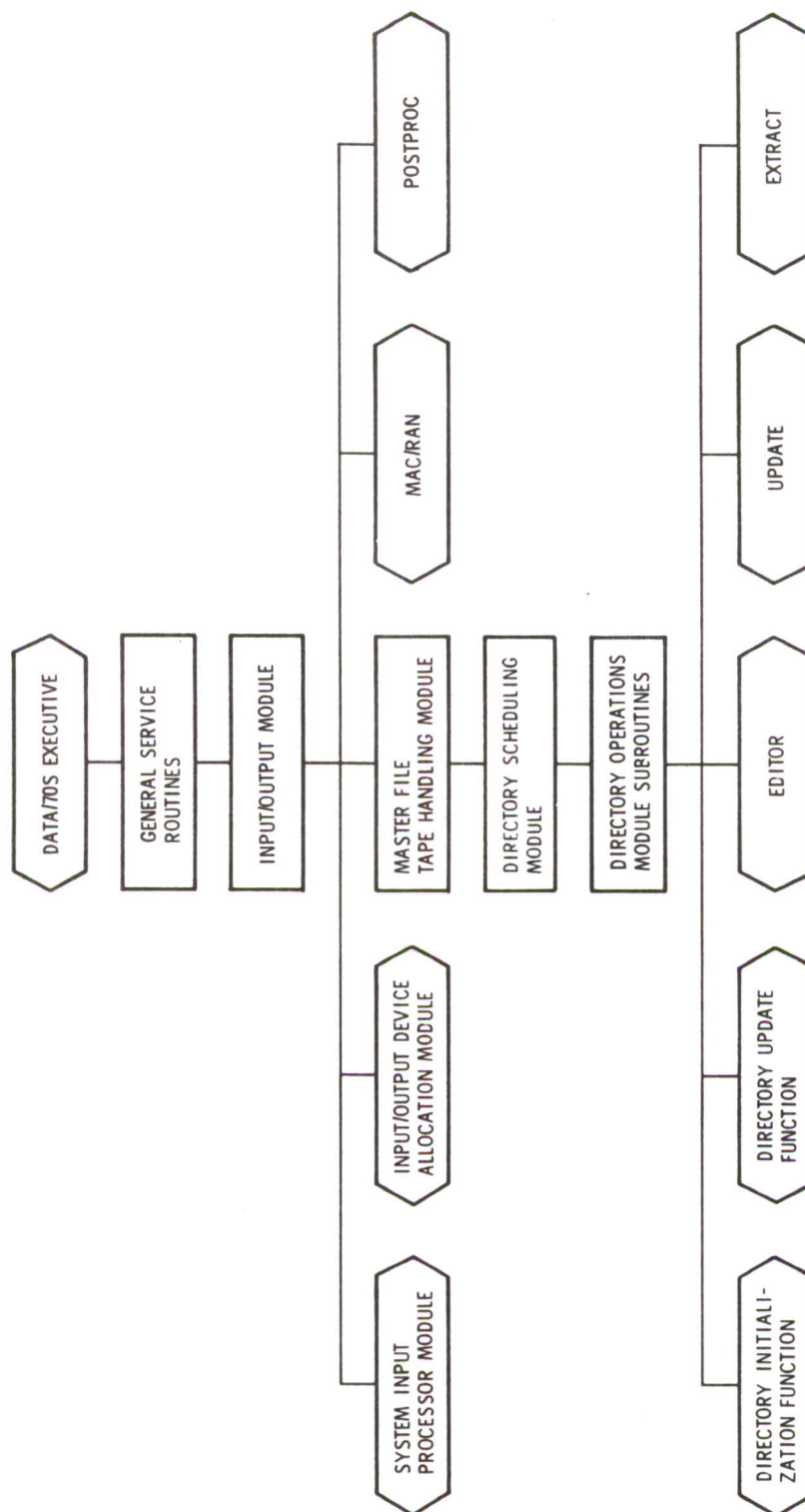


FIGURE B-8. DATA/70S OVERLAY STRUCTURE

to be made to the nominal system-control parameters (including a classified/unclassified flag).

In execution, the program is designed to be fully automated. Console messages are issued instructing the operator when tape mounts are required. The operator is instructed to mount specific Directory tapes and Master File tapes and is told which tape drives require scratches to be mounted. Messages are also provided telling the operator what files have been placed on specific scratch tapes so that in the event of an abnormal program termination, intermediate tapes may be labeled and saved for restart. The operator is always informed of the specific drive or permissible set of drives for all requested tape mounts.

Any abnormal conditions that occur during a run, such as invalid tape labels or unrecoverable parities, cause operator instructions to be displayed along with the possible recovery options that may be selected. Operator instructions to the program are handled through the setting of sense switches.

Some other features of the automated system include:

- Dynamic module allocation of available working storage to optimize core usage
- Automatic tape header-label generation and checking to assure correct tape mounts
- Use of Extended Core Storage on the 6600 and direct access drum features on the 1108
- Restart capability provided at any phase of operation

- User-selected I/O record lengths to allow optimization of file handling for particular computer systems
- Generalized machine-independent, open-ended, core and file sorting routines
- Extensive I/O-error recovery procedures
- A run-simulation capability that may be used to estimate the run time of large Master File UPDATE or EXTRACT runs
- A simulation capability for predicting tape assignments for a specific number of available tape drives
- Computer-independent character manipulation based on the number of characters per computer word
- Program-controlled end-of-reel processing based on tape footage calculations
- Multiple output tape drives for a particular external file to save rewind time (when enough tape drives are available)
- Printed-output page numbering, variable page titling, and line counting

The DATA/70S program is designed to provide a fully automated capability with a simple user/machine interface that frees the data analyst from most of the procedural tasks associated with analyzing large volumes of data and provides him with a fast, efficient means of generating complete and concise results.



## APPENDIX C

### DATA/70S PROCESSING OPTIONS

DATA/70S implements the various processing options available in MAC/RAN via a special language that minimizes and simplifies the execution instructions that are input to the system. (The concept is described in Volume 1, Section 4.) There are four types of executable inputs: (1) Process Control Cards, (2) Management Control Cards, (3) Postprocessing Disposition Cards, and (4) File Identification Cards. It is the purpose of this appendix to completely describe all of the various processing options available in DATA/70S via the Process Control Cards and to briefly describe the modifications that occur to the Identification Indicator as the result of execution.

The Identification Indicator assigned to each new channel of data entered into the Master File is composed of an encoded 20-character alphanumeric array. As data are processed in MAC/RAN in one or more of the processing options, entries or modifications are made to characters 19 and 20 of the original 20-character Identification Indicator, and up to 10 new characters are appended to form a new Identification Indicator of up to 30 characters. Thus, any Identification Indicator that contains an entry in characters 19, or more than 20 characters altogether, must identify processed data. These new characters are added to the original Identification Indicator to provide (1) a permanent record of the processing history associated with each channel of processed data and (2) a unique Identification Indicator entry in the directories for each channel of data that is processed and subsequently returned to the Master File for permanent storage.

The processing options that can be submitted to DATA/70S in the form of Process Control Cards are presented in Table C-1, which shows (1) the corresponding code words, (2) the execution parameters, (3) the modifications to the Identification Indicator, and (4) a brief description of the function to be performed.

Figure C-1(a) shows an example of the Identification Indicator for an unprocessed data file. After subjecting the file to (1) trend removal, (2) Butterworth lowpass filtering, and (3) integration, the new Identification Indicator appears as shown in Figure C-1(b). The code words corresponding to the performed operations are DETN, TFILLP, and PINT, whose symbols are T, L, and I, respectively. The symbol D at character 20 indicates that the original velocity data (V) were integrated to obtain displacement.

(a) For the original data: 

4	2	F	E	V	V	1	0	0	A	1	8	0	R	0	8	5			V
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--	--	---

(b) For the processed data: 

4	2	F	E	V	V	1	0	0	A	1	8	0	R	0	8	5		D	T	L	I
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--	---	---	---	---

FIGURE C-1. ORIGINAL AND MODIFIED IDENTIFICATION INDICATOR

TABLE C-1. DATA/70S PROCESSING REQUEST OPTIONS

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
CALBST	Number of calibration steps Physical unit factors	None	None	None	Step calibrate
CALBSC	Physical unit factors	None	None	None	Continuation of CALBST
CALBSS	Number of calibration steps Physical unit factor	None	None	None	Step and sinusoidal calibration
DECI	Decimation index	None	None	D	Decimation
EDIT	Number of standard deviations Number of points in averaging span Maximum consecutive data replaced Maximum number data replaced	None	None	E	Wild-point editing
DETN	Degree polynomial removed Start time Number of points to fit	None	None	T	Trend removal
DECILP	Decimation index Cutoff frequency Number of points for preload Number of poles	None H	None None	L L	Lowpass tangent filter and decimate; Optionally: filter transfer function gain
FILTLP	Degree polynomial + 1 Decimation index Cutoff frequency Number of points for preload Number of poles	None H	None None	L L	Least squares detrend, Butterworth lowpass sine filter and decimate; Optionally: filter transfer function gain
FILTHP	Degree polynomial + 1 Decimation index Cutoff frequency Number of poles	None H	None None	H H	Least squares detrend, Butterworth highpass sine filter and decimate; Optionally: filter transfer gain
FILTBP	Degree of polynomial + 1 Decimation index Center frequency Bandwidth Number of poles	None H	None None	B B	Least squares detrend, Butterworth bandpass sine filter and decimate; Optionally: filter transfer gain
FILTBR	Degree of polynomial + 1 Decimation index Center frequency Bandwidth Number of poles	None H	None None	J J	Least squares detrend, Butterworth bandreject sine filter and decimate; Optionally: filter transfer gain

TABLE C-1. (CONTINUED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
TFILLP	Degree of polynomial + 1 Decimation index Cutoff frequency Number of points for preload Number of poles	None H	None None	L L	Least squares detrend, Butterworth lowpass tangent filter and decimate; Optionally: filter transfer gain
TFILHP	Degree of polynomial + 1 Decimation index Cutoff frequency Number of poles	None H	None None	H H	Least squares detrend, Butterworth highpass tangent filter and decimate; Optionally: filter transfer gain
TFILBP	Degree of polynomial + 1 Decimation index Center frequency Bandwidth Number of poles	None H	None None	B B	Least squares detrend, Butterworth bandpass tangent filter and decimate; Optionally: filter transfer gain
TFILBR	Degree of polynomial + 1 Decimation index Center frequency Bandwidth Number of poles	None H	None None	J J	Least squares detrend, Butterworth bandreject tangent filter and decimate; Optionally: filter transfer gain
CSFLLP	Degree of polynomial + 1 Decimation index Cutoff frequency Number points for preload Number of poles Ripple index	None H	None None	L L	Least squares detrend, Chebychev Type I lowpass sine filter and decimate; Optionally: filter transfer gain
CSFLHP	Degree of polynomial + 1 Decimation index Cutoff frequency Number of poles Ripple index	None H	None None	H H	Least squares detrend, Chebychev Type I highpass sine filter and decimate; Optionally: filter transfer gain
CSFLBP	Degree of polynomial + 1 Decimation index Center frequency Bandwidth Number of poles Ripple index	None H	None None	B B	Least squares detrend, Chebychev Type I bandpass sine filter and decimate; Optionally: filter transfer gain
CSFLBR	Degree of polynomial + 1 Decimation index Center frequency Bandwidth Number of poles Ripple index	None H	None None	J J	Least squares detrend, Chebychev Type I bandreject sine filter and decimate; Optionally: filter transfer gain

TABLE C-1. (CONTINUED)

Code Word	Parameter	Character			Function
		19	20	21 to 30	
		Symbol			
CTFLP	Degree of polynomial + 1	None	None	L	Least squares detrend, Chebychev Type I lowpass tangent filter and decimate; Optionally: filter transfer gain
	Decimation index				
	Cutoff frequency				
	Number of points for preload	H	None	L	
	Number of poles				
CTFLHP	Ripple index				Least squares detrend, Chebychev Type I highpass tangent filter and decimate; Optionally: filter transfer gain
	Degree of polynomial + 1	None	None	H	
	Decimation index				
	Cutoff frequency				
	Number of poles	H	None	H	
CTFLBP	Ripple index				Least squares detrend, Chebychev Type I bandpass tangent filter and decimate; Optionally: filter transfer gain
	Degree of polynomial + 1	None	None	B	
	Decimation index				
	Center frequency				
	Bandwidth	H	None	B	
CTFLBR	Number of poles				Least squares detrend, Chebychev Type I bandreject tangent filter and decimate; Optionally: filter transfer gain
	Ripple index				
	Degree of polynomial + 1	None	None	J	
	Decimation index				
	Center frequency				
FILTRC	Bandwidth	H	None	J	Least squares detrend, exponential filter and decimate; Optionally: filter transfer gain
	Number of poles				
	Ripple index				
	Degree of polynomial + 1	None	None	L	
	Decimation index				
FILTST	Cutoff frequency	H	None	L	Least squares detrend, single trend filter and decimate; Optionally: filter transfer gain
	Degree of polynomial + 1	None	None	B	
	Decimation index				
	Center frequency	H	None	B	
	Bandwidth				
ZOOM					Frequency band isolation; Optionally: filter transfer gain
	Left frequency bound	None	None	B	
	Right frequency bound	H	None	B	
	Cutoff frequency				
	Number of points for preload				
SPDF	Number of poles				Histogram, probability density function and normality check
	Number of intervals	+, (	None	,	
	Number of data points				
	Left margin				
	Right margin				

TABLE C-1. (CONTINUED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
			Symbol		
FOUR	Size of transform Tapering Starting zoom frequency Stopping zoom frequency Zoom sampling rate	B, C	None	A	Fourier transform, real and imaginary components
FOURIN	Sampling rate	Blank	None	K	Inverse Fourier transform
PSDT	Number of points/segment Tapering index Effective bandwidth Mean removal index Decimation index	G	None	X	Power spectral density
PSDTZM	Starting zoom frequency Stopping zoom frequency Sampling rate	None	None	None	Continuation (zoom only)
CSDTMP	Number of points/segment	X, A	None	X	Cross-spectral densities modulus and phase; Optionally: power spectral densities; transfer function gain; coherence
	Tapering index	G	None	X	
	Effective bandwidth	H	None	X	
	Mean removal index	S	None	X	
CSDTGM	Decimation index				Continuation (zoom only)
	Input-output index				
	Starting zoom frequency	None	None	None	
	Stopping zoom frequency	None	None	None	
TRNTGP	Sampling rate				Transfer function gain and phase; Optionally: power spectral densities; coherence
	Number of points/segment	H, A	None	X	
	Tapering index	G	None	X	
	Effective bandwidth	S	None	X	
TRNTZM	Mean removal index				Continuation (zoom only)
	Decimation factor				
	Input-output index				
	Starting zoom frequency	None	None	None	
COHTOR	Stopping zoom frequency				Ordinary coherence
	Sampling rate				
	Number of points/segment	S	None	X	
	Tapering index				
	Effective bandwidth				
	Mean removal index				
	Decimation factor				
	Input-output index				

TABLE C-1. (CONTINUED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
COHTZM	Starting zoom frequency Stopping zoom frequency Sampling rate	None	None	None	Continuation (zoom only)
CSDTRI	Number of points/segment	D, E	None	X	Cross-spectral density, real and imaginary; Optionally: power spectral densities; transfer function gain and phase; coherence
	Tapering index	G	None	X	
	Effective bandwidth	H, A	None	X	
	Mean removal index	S	None	X	
	Decimation factor				
TRNTRI	Input-output index				Transfer function, real and imaginary; Optionally: power spectral densities; coherence
	Number of points/segment	U, V	None	X	
	Tapering index	G	None	X	
	Effective bandwidth	S	None	X	
	Mean removal index				
PSDF	Decimation factor				Power spectral density
	Starting zoom frequency	G	None	Q	
	Stopping zoom frequency				
CSDFMP	Original sampling rate	D, E	None	Q	Cross-spectral densities, modulus and phase; Optionally: power spectral densities; transfer function gain and phase; coherence
	Type of window	G	None	Q	
	Effective bandwidth	H, A	None	Q	
	Decimation factor	S	None	Q	
	Starting zoom frequency				
TRNFGP	Stopping zoom frequency				Transfer function, gain and phase Optionally: power spectral densities; coherence
	Original sampling rate	H, A	None	Q	
	Type of window	G	None	Q	
	Effective bandwidth	S	None	Q	
	Decimation factor				
COHFOR	Starting zoom frequency				Ordinary coherence; Optionally: power spectral density
	Stopping zoom frequency	S	None	Q	
	Original sampling rate	G	None	Q	
	Type of window				
	Effective bandwidth				
Decimation factor					
Starting zoom frequency					
Stopping zoom frequency					

TABLE C-1. (CONTINUED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
CSDFR I	Original sampling rate	G, D, E	None	Q	Power spectral density and cross-spectral density, real and imaginary; Optionally: transfer function gain and phase; coherence; transfer function, real and imaginary
	Type of window				
	Effective bandwidth	H	None	Q	
	Decimation factor	S	None	Q	
	Stopping zoom frequency	U	None	Q	
TRNFR I	Original sampling rate	U, V	None	Q	Transfer function, real and imaginary; Optionally: power spectral density; transfer function gain and phase; coherence
	Type of window	G	None	Q	
	Effective bandwidth	H, A	None	Q	
	Decimation factor	S	None	Q	
	Stopping zoom frequency				
PADD	None	None	None	*	Addition of pairs of files
PSUB	None	None	None	-	Subtraction of pairs of files
PMUL	None	None	None	*	Multiplication of pairs of files
PDIV	None	None	None	/	Division of pairs of files
PCAD	Value of constant	None	None	0	Addition of a constant
PCMU	Value of constant	None	None	1	Multiplication of a constant
PWIR	Number of duplicates	None	None	None	Duplication of a file
PSIG	None	None	None	4	Signed step function
PABS	None	None	None	5	Absolute value
PLOG	None	None	None	6	Natural log
PEXP	None	None	None	7	Exponential
PPOW	Value of power	None	None	8	Raise to a power
PSQT	None	None	None	9	Square root
PSIN	None	None	None	=	Sine
PCOS	None	None	None	(	Cosine
PATN	None	None	None	)	Arctangent
PDEL	First data value of delayed file	None	None	S	Delay by one ΔT

TABLE C-1. (CONTINUED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
PFILRC	Value of filter constant	None	None	L	Exponential filter
PINT	None	None	P → I A → V V → D	I	Integration
PDIF	None	None	I → P V → A D → V	Z	Differentiation
PFILLP	Cutoff frequency Number of poles	None	None	L	Butterworth lowpass sine filter
PFILHP	Cutoff frequency Number of poles	None	None	H	Butterworth highpass sine filter
PFILBP	Center frequency Bandwidth Number of poles	None	None	B	Butterworth bandpass sine filter
PFILBR	Center of frequency Bandwidth Number of poles	None	None	J	Butterworth bandreject sine filter
PTIMAD	Value of constant	None	None	P	Addition of a constant to time
PTIMMU	Value of constant	None	None	Φ	Multiplication of time by a constant
PRAN	None	None	None	None	Replace data with uniform random values
PMAC	Value of constant	None	None	2	Multiply first file of a pair by a constant and add to a second file
PMAD	None	None	None	3	Multiply first two files of a group of three and add to the third file
PSTC	Value of constant Start time Stop time	None	None	S	Replace data with a constant
PGAU	None	None	None	None	Replace data with Gaussian random values
CADD	None	None	None	+	Complex addition of pairs of files
CSUB	None	None	None	−	Complex subtraction of pairs of files

TABLE C-1. (CONTINUED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
CMUL	None	None	None	*	Complex multiplication of pairs of files
CDIV	None	None	None	/	Complex division of pairs of files
CCAD	Value of real constant Value of imaginary constant	None	None	0	Addition of a complex constant
CCMU	Value of real constant Value of imaginary constant	None	None	1	Multiplication by a complex constant
CONJ	None	None	None	G	Complex conjugate
CPOL	None	U, V → H, A B, C → F, P D, E → X, A	None	F	Conversion to polar coordinates
CREC	None	H, A → U, V F, P → B, C X, A → D, E	None	Y	Conversion to rectangular coordinates
CLOG	None	None	None	6	Complex natural log
CEXP	None	None	None	7	Complex exponential
CSTC	Value of real constant Value of imaginary constant Start time Stop time	None	None	S	Replace complex data with a complex constant
PIND	Value of increment Start value	None	None	None	Replace data value with linear functions
CONF	Type of computation Number of data points Starting value of output independent variable Convolution/correlation index	None	None	V	Convolution
FUNCIN	y <sub>1</sub> , y <sub>2</sub> , y <sub>3</sub> , y <sub>4</sub> , y <sub>5</sub> , y <sub>6</sub> , y <sub>7</sub>	None	None	None	Replace data with input function
FUNCINC	y <sub>8</sub> , y <sub>9</sub> , y <sub>10</sub> , y <sub>11</sub> , y <sub>12</sub> , y <sub>13</sub> , y <sub>14</sub>	None	None	None	Continuation of previous card
FUNCMR	Output device index	None	None	None	Prepare data for MAC/RAN stand-alone

TABLE C-1. (CONTINUED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
OUTPPL	Plot height Plot width Axis type indicator {X max or {X log cycle X origin {Y max or {Y log cycle Y origin	None	None	None	Intermediate plotting
OUTPPR	None	None	None	None	Intermediate printing
OUTPPP	Plot height Plot width Axis type indicator {X max or {X log cycle size X origin {Y max or {Y log cycle Y origin	None	None	None	Intermediate printer plots
CORRAU	Normalizing index Maximum time delay	R	None	R	Autocorrelation
CORRCR	Normalizing index Maximum time delay	Q Q, R	None None	R None	Cross-correlation Optionally: autocorrelation
BTPS	Maximum time delay Computation bandwidth Start frequency Number of frequency components Smoothing index	G	None	R	Power spectral density
BTCS	Maximum time delay Computation bandwidth Start frequency Number of frequency components Smoothing index Normalizing index	X, T, G	None	R	Power spectral density and cross-spectral density modulus and phase; Optionally: auto and cross correlations
LINS	Coherency confidence interval Frequency response confidence interval Output function index	S, Z, Y H, A	None	U	Ordinary coherence, multiple coherence, partial coherence, and transfer function gain and phase

TABLE C-1. (CONTINUED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
ENAV	Number of functions Previous sum or mean Previous sum of squares or mean squares	H, N J, W L	None	W	Ensemble mean, mean square sum, sum of squares, and variance
ENAVTA	Advance coefficients	None	None	None	Input time advance
ENAVTAC	Advance coefficients	None	None	None	Continuation
ENAVSA	Scale alignment terms	None	None	None	Input scale alignment coefficients
ENAVSAC	Scale alignment terms	None	None	None	Continuation
ENAVWT	Weighting factors	None	None	None	Input weight coefficients
ENAVWTC	Weighting factors	None	None	None	Continuation
SHOXDE	Number of damping ratios Lowest damping ratio Damping ratio increment Number of natural frequencies Lowest natural frequency Frequency increment Excitation delay time	K	D	•	Shock spectrum analysis of relative deflection
SHOXDEC	Length of residual time Output amplitude index Input type index Front end taper factor Rear end taper factor	None	None	None	Continuation
SHOXVE	Number of damping ratios Lowest damping ratio Damping ratio increment Number of natural frequencies Lowest natural frequency Frequency increment Excitation delay time	K	V	•	Shock spectrum analysis of pseudo-velocity
SHOXVEC	Length of residual time Output amplitude index Maximum pressure Input type index Front end taper factor Rear end taper factor	None	None	None	Continuation

TABLE C-1. (CONTINUED)

Code Word	Parameter	Character			Function
		19	20	21 to 30	
		Symbol			
SHOXAC	Number of damping ratios Lowest damping ratio Damping ratio increment Number of natural frequencies Lowest natural frequency Frequency increment Excitation delay time	K	A	•	Shock spectrum analysis of equivalent static acceleration
SHOXACC	Length of residual time Output amplitude index Maximum pressure Input type index Front end taper factor Rear end taper factor	None	None	None	Continuation
SHTHDE	Damping ratio Natural frequency Type of input index Front end taper Rear end taper	Φ	D	•	Relative deflection
SHTHVE	Damping ratio Natural frequency Type of input index Front-end taper Rear end taper	Φ	V	•	Pseudovelocitv
SHTHAC	Damping ratio Natural frequency Type of input index Front-end taper Rear-end taper	Φ	A	•	Equivalent static acceleration
RMST	RMS time history Integration time	I	None	M	Root mean square
TOCTPD	Highest mean frequency Number of octaves	G	None	M	One-third octave power spectral density
TOCTRD	Highest mean frequency Number of octaves	O	None	M	One-third octave root-mean-square spectral density
TOCTPS	Highest mean frequency Number of octaves	1	None	M	One-third octave power spectrum
TOCTRS	Highest mean frequency Number of octaves	2	None	M	One-third octave root-mean-square spectrum

TABLE C-1. (CONCLUDED)

Code Word	Parameters	Character			Function
		19	20	21 to 30	
		Symbol			
TOCTFL	Highest mean frequency	3	None	M	One-third octave filter
TOCTFM	Highest mean frequency	4	None	M	One-third filtered mean square
TOCTFR	Highest mean frequency	5	None	M	One-third filtered root mean square
PLTF	Lower clamping frequency Upper clamping frequency Starting frequency Sensitivity multiplier Decimation index Cutoff frequency Number of poles	6, 7, F	None	N	Simple phase-lock-loop tracking filter generating frequency lock and amplitude
PLTFAB	Lower clamping frequency Upper clamping frequency Starting frequency Sensitivity multiplier Decimation index Cutoff frequency Number of poles	6, 7 F, S, P H, A	None	N	Phase-lock-loop tracking filter with tracking function generating frequency, lock amplitude, coherence, phase, amplitude ratio, relative phase, and harmonic amplitudes
PLTFAL	Lower clamping frequency Upper clamping frequency Starting frequency Sensitivity multiplier Decimation index Cutoff frequency Number of poles	6, 7 F, S, P	None	N	Phase-lock-loop tracking filter with tracking function generating frequency, lock amplitude, coherence phase and amplitude phase, amplitude ratio and relative phase for fundamental and harmonics
PLTFHR	1-7 harmonics	None	None	None	Input harmonic values for PLTFAR and PTLFAL
PLTFHRC	8-14 harmonics	None	None	None	Continuation
CRSH	Y axis increment Minimum Y value Maximum Y value Maximum X value H. I. C. index	+	None	,	Histogram

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